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ACOS Level 2 Standard Product Data User's Guide, v2.9

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Goddard Space Flight Center
Greenbelt, Maryland

Jet Propulsion Laboratory
Pasadena, California

Prepared By:

Greg Osterman, JPL
ACOS, OCO-2 Science Validation Lead

Annmarie Eldering, JPL
OCO-2 Deputy Project Scientist

Charles Avis, JPL
ACOS, OCO-2 Science Data Operations System

Christopher O'Dell, CSU
ACOS Algorithms Team

Elmain Martinez, JPL
ACOS Science Data Operations System

David Crisp, JPL
OCO-2 Science Team Lead

Revision History

Revision Date	Changes	Author
1 October 2010	Initial Release	C. Avis
20 December 2010	Updates to most sections including changes to ACOS metadata/elements based on the v2.8.00 delivery. Updated quality provided by G.Osterman.	E. Martinez
30 October 2011	Complete revision of document. Includes updates for Build 2.9	E. Martinez
29 November 2011	Rev B: Updated links to Mirador, corrected typos	E. Martinez
7 December 2011	Rev C: corrected typo on page 17 and added additional instructions on how to get data in section 4. ACOS release v2.9	E. Martinez
26 October 2012	Rev D: Updated to further describe experience with v130130 data, and the preliminary experience with v15015x. Additional information about biases between Gain H and Gain M has been added. Errors associated with geolocation uncertainties also added. ACOS release v2.9	D. Crisp

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1. Introduction

1.1. Scope and Background

This document is intended to provide an overview of the v2.9 Atmospheric CO_2 Observations from Space (ACOS) data product, key features and issues, preliminary validation information, recommendations on data usage, as well as background on the Greenhouse Gases Observing Satellite (GOSAT) mission measurements and the ACOS algorithm. The later sections provide the reader with information on filename conventions and a detailed guide on the format and fields in the hdf product.

This is the third 'public release' of ACOS data, the previous version being v2.8, which was released beginning in February 2011. The v2.8 data are described in a series of validation papers published in 2011. This document updates findings from these papers for v2.9, and gives more general information on the use of ACOS data.

1.2. Overview of Document

The remainder of this section describes the usage of the ACOS data. Section 2 provides details of the differences in this version, product characteristics, validation status, key data fields and ends with recommendations for data analysis. Section 3 provides background information on the GOSAT mission, ACOS file and data conventions, and a complete listing of metadata elements in the v2.9 ACOS data product. Section 4 lists tools to view and search the data products. Section 5 lists contact information for both GOSAT and ACOS data, and the last section lists acknowledgements and relevant publications.

1.3. Data Usage Policy

This data has been produced by the ACOS project, and is provided freely to the public. The ACOS project has been made possible by the generous collaboration with our Japanese colleagues at Japanese Aerospace Agency (JAXA), National Institute for Environmental Studies (NIES), and the Ministry of the Environment (MOE). The L1 data have been made available for this project through an RA agreement between the GOSAT Three Parties and Caltech. To improve our product and have continued support for this work, we need user feedback and also have users acknowledge data usage. Therefore, we request that when publishing, please acknowledge NASA and the ACOS/OCO-2 project.

- Include OCO-2 as a keyword to facilitate subsequent searches of bibliographic databases if it is a significant part of the publication
- Include a bibliographic citation for ACOS/OCO-2 data. The most relevant citations currently are Wunch et al (2011), O'Dell et al (2011) and Crisp et al. (2012).
- Include the following acknowledgements: "These data were produced by the ACOS/OCO-2 project at the Jet Propulsion Laboratory, California Institute of Technology, and obtained from the ACOS/OCO-2 data archive maintained at the NASA Goddard Earth Science Data and Information Services Center."
- Include an acknowledgement to the GOSAT Project for acquiring these spectra.
- We recommend sending courtesy copies of publications to the OCO-2 Project Scientist, Michael.R.Gunson@jpl.nasa.gov.

2. V2.9 ACOS L2 Data Products

2.1. Differences Between v2.8 and v2.9

The following is a summary of the key L1B changes made in v2.9 compared to v2.8. Note that more details of the L1B versions are included in Section 3.2.

- In v2.8, time-varying radiometric throughput degradation coefficients received from JAXA in November 2010 were applied to radiances but not to the noise estimate. As a result, the spectral radiance appeared to decrease relative to the noise, reducing the number of v2.8 retrievals that passed the spectral fitting criterion (χ^2) over time. In v2.9, the time-dependent radiometric degradation is applied to both the radiances and the noise estimate, so there is no longer a time dependence in the number of data passing the spectral fitting criteria.
- Custom glint flag calculation: In v2.8, the JAXA-defined glint flag was used to select data for processing as glint. Due to an error in that flag (that continues to exist in all L1B products delivered prior to version v150151), this resulted in missing glint data, with more and more data missing over time. We now implement a custom flag for glint, and have full coverage.
- Added L1B noise elements with _l1b suffix.
- Added geometric correction factors to L1B geolocation, based on pointing correction files delivered in December 2010. These static correction tables apply a geolocation correction to each footprint, depending on the along-track and cross-track angles. This provides an adequate correction for data acquired prior to January 2011, but introduce pointing errors for later dates, because the along-track and cross-track pointing errors change over time.
- JAXA began delivering a new L1B product, v150150 (algorithm version 150, parameter version 150) starting on 19 April 2012. This product was revised with modified parameters to fix the glint flag anomaly on 20 June 2012 and called, v150151. These products include the following changes that affect the ACOS L2 processing:

  1. An improved correction to the Band-1 analog circuit non-linearity
  2. A correction to the interferogram sampling interval non-uniformity
  3. Improved scan speed instability correction for the Band-1 medium gain (Gain M) data

  ACOS v2.9 product deliveries were suspended from 19 April 2012 pending the validation of the L2 products generated with this new L1B product. Deliveries were resumed mid-September of 2012.
- The GOSAT Project Team is currently reprocessing all of the GOSAT products using v150151. The ACOS team plans to use v2.9 to reprocess and deliver the products originally generated from L1B v130130 (April 20, 2011 – April 18, 2012), which introduced large biases in the L2 products.

Changes to the L2 products are as follows:

- Significantly affecting the retrieval results
  - Retrieved a constant zero-level offset correction in the A-band to reduce the signal level dependent bias in the O_2 A-band that is caused by the Band-1 analog signal nonlinearity. By adding a flat, zero-level offset term in the state vector and fitting for

it, many systematic biases were eliminated. However, this correction has increased the differences between retrievals of M and H-gain data.
  - Rescaled O_2 A-band cross sections with a constant factor of 1.025 to reduce the 10hPa surface pressure bias seen in v2.8. The mean surface pressure is now unbiased & retrieved aerosols optical depths are somewhat lower; X_{CO2} is in better agreement with ground based Total Carbon Column Observation Network (TCCON) data. The scaling of the O2-A band increased the X_{CO2} values by approximately 4 to 5 ppm.
  - Added ILS interpolation. Previously, the tabulated instrument line shape (ILS) data were assumed to be constant over fixed wavenumber ranges. They are now interpolated linearly between the wavenumbers tabulated in the ILS calibration tables. This change increased the retrieved X_{CO2} estimates by1.5ppm, bringing them closer to TCCON estimates, and reducing the scatter in the retrievals.
  - Glint noise treatment: In v2.8, the ocean scenes were assigned noise values supplied by JAXA, and had very large values of chi-squared, whereas the land scenes had an empirical noise applied, which was more consistent across bands and resulted in chi-squared values close to 1. In v2.9, the empirical noise has been applied to both the ocean and land scenes.
  - Cloud screening applied to glint and land data in preprocessing. In v2.8, it was applied only to the land data in preprocessing.

- Within the code
  - Static input data moved to a single HDF file
  - Upgraded LIDORT version to 3.5T
  - Reworked Jacobian calculations to use automatic derivatives

- Instrument capability
  - Added support for FTS Instrument in up-looking mode
  - Added support for OCO-2 instrument mode

- Speed improvement
  - Use only two streams in the Low Streams Interpolator (LSI) part of the radiative transfer code when a low number of streams is required (was 4 previously).

- Spectroscopy
  - Version 3.3 ABSCO tables were used

2.2. Validation Status

The version 2.9 ACOS X_{CO2} data product was initially validated using roughly 15 months of data, but this validation data set used only H gain soundings over land. Validation against TCCON data shows that the v2.9 X_{CO2} products have largely eliminated the ~7 ppm bias seen in v2.8.About half of this bias was contributed by the O_2 cross section uncertainties that produced the 10 hPa surface pressure bias. Most of the rest was associated with the approach used to interpolate the ILS values and between the values specified in the calibration tables, and uncertainties in the CO_2 absorption coefficients. The v2.9 products also have up to a factor of two less scatter than v2.8. (see Figure 1). The mean global bias is now about 0.13 ppm (1.97 ppm standard deviation), though that number does have a small seasonal variation. Figure 2 shows a histogram of the differences between TCCON and ACOS estimations of XCO_2.

A monthly bias estimates for v2.9 X_{CO2} are shown for several TCCON stations in Table 1. The bias calculation uses only 12 months of data. A full analysis of the bias will be performed upon completion of the v2.9 processing. The values quoted in the table are monthly mean biases in X_{CO2} (TCCON-ACOS). The coincidence criteria use ACOS products retrieved from H-gain sounding collected over land within 3 hours and 500 km (radius) of the TCCON site. The seasonal variation in the bias can be seen in Table 1 and also in Figure 3, which shows the comparison for the Lamont site (same coincidence criteria as the table).

The key features of the approach for validating the ACOS X_{CO2} product is described in Wunch et al., (2011). The paper describes a method of evaluating systematic errors in space based column CO_2 measurements. The authors use the uniformity in X_{CO2} between 25° S and 55° S, to identify biases due to retrieval or instrument effects in the ACOS products. First applying multivariate linear regression analysis to ACOS product (after removing the larger bias in the v2.8 X_{CO2}), the authors showed that the remaining bias can be partially removed by applying corrections related to blended albedo (defined in section 2.5.1 below), surface pressure error, airmass and signal in the oxygen band. Definitions of the regression terms are provided in equations 1-4 of Wunch et al., (2011).

Wunch et al. (2011) show that the same four parameters can be used to remove much of the bias from v2.9, but the regression coefficients change somewhat. Preliminary analysis using v2.9 data also shows that "blended albedo" can be replaced by using only the oxygen band albedo.

Table 1. Total mean bias between ACOS v2.9 and TCCON data (Column 2) and monthly mean bias.

Site	Mean Bias	2009 July	2009 Aug	2009 Sep	2009 Oct	2009 Nov	2009 Dec	2010 Jan	2010 Feb	2010 Mar	2010 Apr	2010 May	2010 June	2010 July
Eureka	-1.56													-1.0
Sodankyla	-2.11											-2.1	-2.4	-0.8
Orleans	0.1			0.2	0.2	1.2			3.4	3.0	-0.3		-3.1	-2.0
Garmisch	-0.99		-0.6	0.1	-0.8					1.4	-1.2	-2.4	1.0	-3.1
Park Falls	-0.07	0.8	0.9	0.1	1.0	0.7				1.4	-0.2			
Lamont	0.91	0.6	0.3	-0.2	-0.1	0.8	2.4	2.0	2.2	2.1	1.1	-0.2	1.1	0.2
Tsukuba	-0.94		1.3	-2.0	-1.4	-1.8	-0.4	-1.2	-0.2	-0.6				
Darwin	0.66	0.7	0.6	0.7		1.3								
Wollongong	-0.92	-1.5	-1.7	0.2		-1.5	-2.2			-0.4	-0.7			-0.5
Lauder	-0.59			-1.1					-0.3			-0.2		

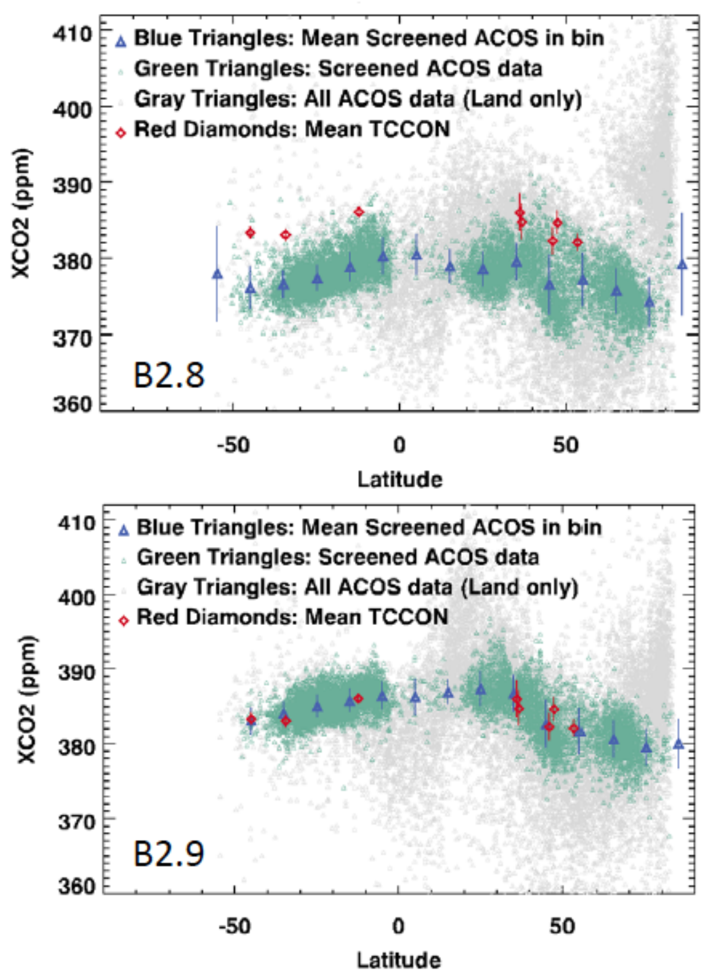

Figure 1. Comparison of ACOS v2.8 (top panel) and v2.9 (bottom panel) XCO2 data compared to TCCON. The consistent (~7 ppm) bias seen in v2.8 has been removed in v2.9.

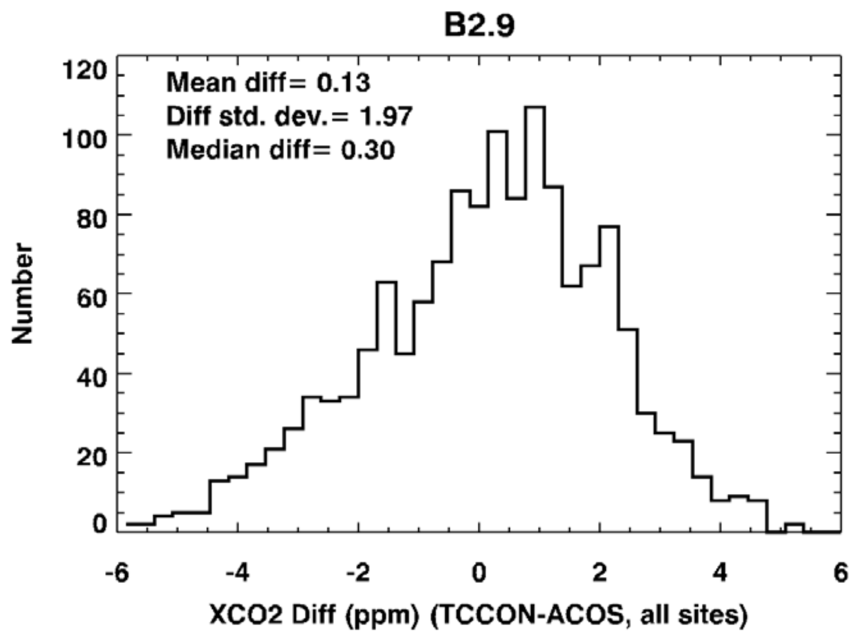

Figure 2. Histogram of the difference between TCCON and ACOS for all TCCON sites used in the analysis.

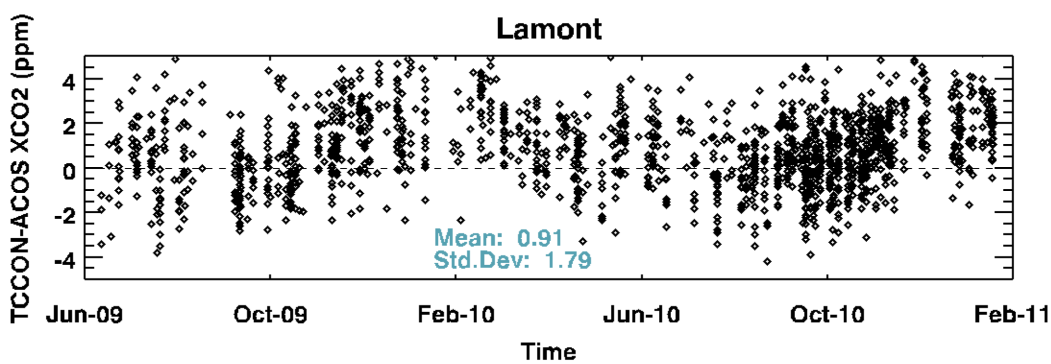

Figure 3. Time series of the bias in ACOS relative to TCCON (TCCON-ACOS) for the TCCON site in Lamont, OK.

2.3. Data Description and User Alerts

The products generated by the ACOS software *build_id* v2.9.00 have the following characteristics that the user should be aware of:

Biases between Gain-H and Gain-M: GOSAT data are taken in two gain settings: Medium (M) over bright land surfaces (typically desert regions), and High (H) over all other surfaces. It has been found that while the newly-implemented zero-level-offset (ZLO) fit in the oxygen-A band typically finds positive ZLO for H-gain soundings, a negative ZLO is typically retrieved for M-gain soundings. This negative ZLO drives the retrieved surface pressure negative, such that there is a roughly -5 hPa bias in the retrieved surface pressure for M-gain soundings (Figure 4). This leads directly to a +1.5 ppm average bias in X_{CO2} for M-gain soundings. Users should therefore use caution when attempting to use M-gain data; they may wish to abandon it altogether, or apply their own bias-correction scheme to put it on the same footing as H-gain observations.

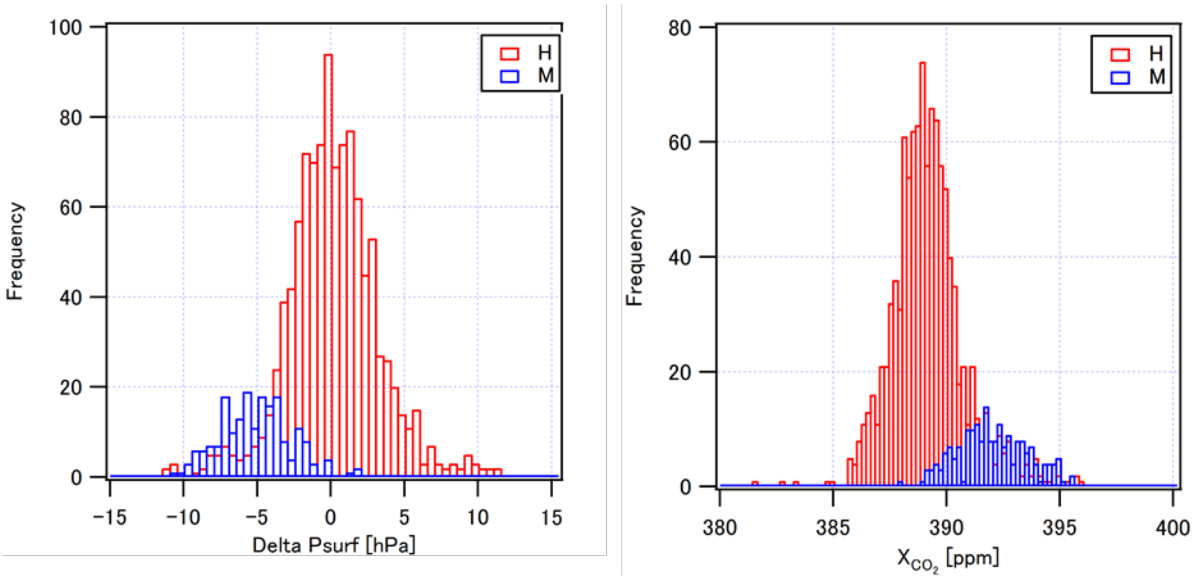

Figure 4. Bias in surface pressure (a) and X_{CO2} (b) for Gain H (red) and Gain M (blue) for soundings collected over Australia.

Geolocation Errors: The GOSAT TANSO-FTS pointing errors have continued to evolve over time. To track and correct for these variations, JAXA has used images collected a camera installed within the TANSO-FTS to image the actual bore sight. These images are compared to known topographic features (e.g. shore lines) and with images collected by the TANSO-CAI to track changes in the intended TANSO-FTS pointing. Pointing changes are documented in tables and figures (e.g. Figure 5) that are distributed to the GOSAT user community periodically. All current pointing estimates in the v2.9 product were corrected using geolocation correction tables delivered in late 2010. The pointing offsets changed abruptly in late of December 2010. The values used in v2.9 overestimate the pointing offsets through July 2011 by about a factor of 3. TANSO-FTS pointing offsets have changed more than a dozen times since then, but have mean values near those adopted for v2.9 (Figure 5).

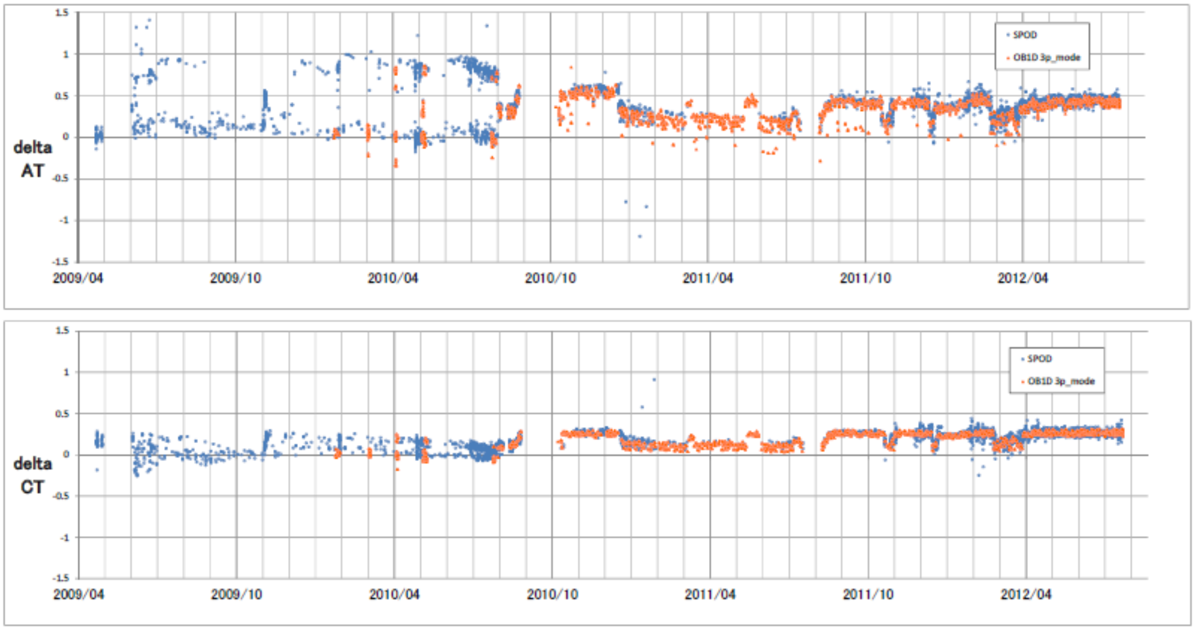

Figure 5. Time dependent pointing errors in the Along-Track (delta AT) and Cross-Track (delta CT) directions between April 2009 and August 2012 for the Specific Point Observations (SPOD) and Lattice Point Observations (OB1D). The change from 5 cross-track points to 3 cross-track points on 1 August 2010 substantially reduced the scatter in the pointing errors. ACOS v2.9 product assumes a constant offset for all data taken in 3- and 5-point mode. All results for 3-point mode use the offsets estimated for November 2010.

Data Completeness/Coverage

- The first three months of GOSAT operations (April-May, 2009) have incomplete operational coverage due to on-orbit calibrations and checkout activities. Full coverage begins about 1 July 2009.
- Level 2 Data using GOSAT L1B version 130130 (April 20, 2011 through April 18, 2012) were retrieved and data products were delivered to the GES DISC.
- Level 2 Data using GOSAT L1B version 150150 (April 20, 2012 through June 20, 2012) were retrieved and data products delivered to the GES DISC.
- The ACOS Project plans to generate Level 2 products for all available operational GOSAT data (assuming all corresponding ancillary data sets are available).
- Typically data products contain 10-100 useful soundings per orbit, out of the 600-700 L1B soundings collected in an orbit. Note that over 50% of the data is not processed because it does not pass the first cloud screening pre-processing step. A large fraction of data is collected over ocean but not in glint, and thus is not processed. Of the ~100 soundings that are processed for each orbit, convergence and quality screens identify about 20% of that data as good. This is composed of about 15% good soundings over land and 5% over ocean.

- If data users create maps of the filtered v2.9 carbon dioxide data, they should expect to see glint measurements move north and south during the year. Preliminary maps of the v2.9 X_{CO2} retrievals are shown in Figure 6. The monthly mean X_{CO2} maps of the ACOS v2.9 data include both nadir and glint soundings. Each symbol on the map indicates the average of all X_{CO2} estimates in a 2° x 2° bin for that month that passed all pre- and post-screening filters.

Cloud Screening

- To further reduce the computation time of retrievals containing clouds, the cloud screening algorithm is applied to this version. It performs a fast, Oxygen A-band only clear-sky retrieval for surface pressure, surface albedo, temperature offset and dispersion multiplier. The retrieved surface pressure and albedo information are combined with the X{2} goodness-of-fit statistic and signal-to-noise ratio to determine if a scene is clear(0), cloudy (1), or skipped (2). See Section 6 for a paper on this topic.

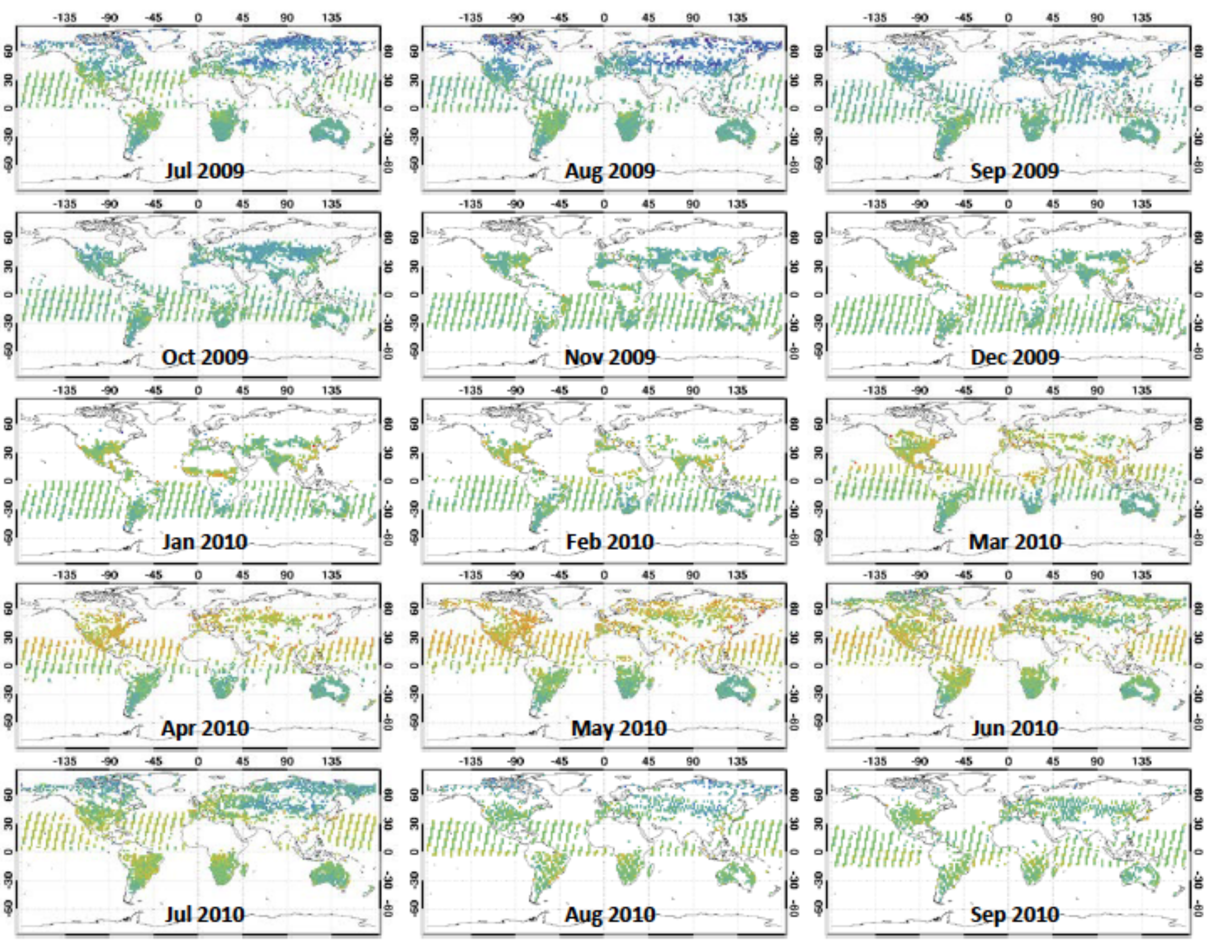

Figure 6. Monthly maps of the ACOS v2.9 X_{CO2} data. Each data point contains the average value for X_{CO2} estimates in a 2° x 2° bin for that month that passed all pre- and post-screening filters.

Post-Processing

- No bias correction – the retrieval results have not been systematically corrected based upon some known reference source
- No post-screening – the results include all soundings whose retrieval converged.
- No post-processing filter has been applied to eliminate soundings based upon certain criteria.

Quality Flagging

- There are several quality flags among the variables. The user should weigh the following information about the flags:
  - *Retrieval_header/sounding_qual_flag* – quality of input data provided to the retrieval processing
  - *Retrieval_results/outcome_flag* – retrieval quality based upon certain internal thresholds (not thoroughly evaluated)
  - *Retrieval_results/master_quality_flag* - four possible values: "Good", "Caution", "Bad", and "Failed" as determined from other flags in the L2 product (see Section 2.3.4)

Averaging Kernels

- The data files include a column averaging kernel value for each retrieved sounding.
- The normalized Averaging Kernel (retrieval_results/xco2_avg_kernel_norm) for a given pressure level is equal to the non-normalized value (retrieval-results/xco2_avg_kernel) divided by the pressure weighting function at that level.

Known Problems

- Content issues
  - The unit listed for *xco2, xco2_apriori, xco2_uncert, co2_profile, co2_profile_apriori, co2_profile_uncert, xco2_uncert_noise, xco2_uncert_noise_smooth and xco2_uncert_noise_interf* is 'VolumeMixingRatio'. The more accurate unit is Mole Fraction with respect to dry air (Mole Mole^{-1}).
- ACOS v2.9 was derived from several different versions of the GOSAT L1B product (v050050, v080080, v100100, v110110, v130130, and v150150). The v130130 product included an initial attempt to correct the Band-1 nonlinearity error, that is responsible for producing the observed zero level offsets in the O_2 A-band spectra. Unfortunately, this correction introduced systematic errors in v130130 spectra that produced large biases in the L2 products generated from this version of the L1B product. L2 products were generated from L1B v130130 for the period extending from 20 April 2011 through 18 April 2012. These products are not useful for scientific purposes. The GOSAT Project Team has recently replaced this product with L1B v150151 products. The ACOS team is reprocessing all L2 data generated during this period with v2.9, as well as continuing the forward processing with this version.
- Other

- Pointers to other files (e.g., 'InputPointer') are not useful because those files reside only on the originating system and were not delivered to the GES DISC
- The glint flag field does not properly indicate which measurements are taken in glint mode. Use the filter described in Section 2.5.2 instead.

Unassessed Issues

- Only a preliminary assessment of the L2 data products derived from the L1B v150150 and v150151 products has been performed. These tests indicate that the L2 products retrieved from these revised L1B products are very similar to v100100 and v110110 products, typically agreeing to within ±1 ppm. The retrieved Band-1 zero level offsets are smaller for Gain H, but have not changed substantially for Gain M. These changes have slightly increased the differences between the Gain H and Gain M retrievals. These v150150 validation tests also revealed a low-amplitude "ringing" in Bands 2 and 3, which can increase the spectral residuals in these bands. This artifact has been traced to the interferogram sampling interval non-uniformity correction introduced in v150150. These two issues are currently under investigation.

2.4. Key Science Data Fields

2.4.1. Retrieval_results/xco2

The Level 2 Standard Product contains the variable X_{CO2}. This variable expresses the column-averaged CO_2 dry air mole fraction for a sounding. Those soundings that did not converge will not be present. These values are determined by a full-physics retrieval and have units of mol/mol.

2.4.2. Sounding_header/cloud_flag

The Level 2 Standard Product contains the variable *cloud_flag*. This variable expresses the result of an analysis of cloud contamination within a sounding. Every sounding of a granule will have a value: 0 (Clear), 1 (Cloudy) or 2 (Undetermined). The values are determined by an ABO2-band-only retrieval using the FTS spectrum. Only soundings with a value of 0 (Clear) have been processed by the L2 algorithm.

2.4.3. Retrieval_results/surface_pressure_fph

The Level 2 Standard Product contains the variable *surface_pressure_fph*. This variable expresses the retrieved atmospheric pressure at the Earth's surface for a given sounding. Those soundings that did not converge will not be present. These values are determined by a full-physics retrieval and have units of Pascals.

2.4.4. Retrieval_results/master_quality_flag

The original intention of this flag was to provide general post-processing screening criteria for the Level 2 ACOS X_{CO2} retrievals. However, detailed science analysis using the v2.9 data has shown that a more rigorous screening formulation is necessary to properly screen the data. The ACOS Science team recommends the user screen the data using the method provided in Section 2.5.1. With the master quality flag, there are four possible values: "Good", "Caution", "Bad", and "Failed". The latter case should be rare, but would indicate a problem in the sounding when it was being aggregated into the HDF product.

A "Good" retrieval needs to meet criteria in four areas:

- Cloud screen
- Retrieval success
- Clear sky conditions and surface elevation consideration
- Acceptable algorithm diagnostics

If the retrieval passed the cloud screen and retrieval success tests, but not the final two tests, it is flagged with a "Caution". If the retrieval did not pass the cloud screen and retrieval success tests it is flagged as "Bad".

The master_quality_flag is created from fields in the L2 data product. These fields and the screening criteria are shown in Table 2.

Table 2. Criteria for the L2 master_quality_flag in the v2.9 data

Field Description	HDF Field	Value for Good Retrieval
Sounding_header/Cloud Flag	cloud_flag	0
Retrieval_results/Retrieval Outcome	outcome_flag	= 1 or 2
Spectral_parameters/Chi Squared O2	reduced_chi_squared_o2_fph	< 1.2
Spectral_parameters/Chi Squared Weak	reduced_chi_squared_weak_fph	< 1.6
Spectral_parameters /Chi Squared Strong	reduced_chi_squared_strong_fph	< 1.8
Doubtful Sounding Criteria		
Field Description	**HDF Field**	**Value for Good Retrieval**
Retrieval_results/Total AOD Retrieved	retrieved_aerosol_aod_by_type	< 0.15
Retrieval_results/Surface Pressure Error	surface_pressure_fph – surface_pressure_apriori_fph	-12 – 12 hPa -1200 – 1200 Pa
Retrieval_results/XCO2 a posteriori error	xco2_uncert	< 1.5 ppm
Retrieval_results/Number of diverging steps	diverging_steps	<= 1

2.5. Science Analysis Recommendations

2.5.1. Data Screening beyond the master quality flag

A more rigorous set of screening criteria incorporating additional data fields has been developed for use in scientific analysis. This post processing screen can be used for both nadir and glint data. Good soundings will be ones that pass all the criteria in Table 3. The screen has been shown to pass 38% of glint soundings and 14% of nadir soundings for a subset of the data.

Table 3. Advanced screening criteria for the L2 in the v2.9 data

Field Description	HDF Field	Value for Good Retrieval
Sounding_header/Cloud Flag	cloud_flag	0
Retrieval_results/Retrieval Outcome	outcome_flag	= 1 or 2
Spectral_parameters/Chi Squared O2	reduced_chi_squared_o2_fph	< 1.4
Spectral_parameters/Chi Squared Weak	reduced_chi_squared_weak_fph	< 2.0
Spectral_parameters/Chi Squared Strong	reduced_chi_squared_strong_fph	< 2.0
Retrieval_results/Total AOD Retrieved	retrieved_aerosol_aod_by_type	< 0.15
Retrieval_results/Surface Pressure Error	surface_pressure_fph – surface_pressure_apriori_fph	-10 – 10 hPa -1000 – 1000 Pa
Retrieval_results/XCO2 a posteriori error	xco2_uncert	< 1.3 ppm
Retrieval_results/Number of diverging steps	diverging_steps	<= 2
Retrieval_results/Albedo of CO_2 Strong	albedo_strong_co2_fph	> 0.05 *
Blended Albedo	See below	< 1 **
Retrieval_results/Degrees of Freedom	dof_co2_profile	> 1.15 **
* Not used for glint		
** Should not have an effect on glint screening		

The blended albedo screening parameter is a mixture of several albedo terms in the data product files. It can be calculated by using the following relationship:

$$\text{blended albedo} = 2.4A_{O2A} - 1.13A_{SCO2} < 1$$

where A_{O2A} is the albedo for the O2 A band (retrieval_results/albedo_o2_fph) and A_{SCO2} is the albedo in the strong CO_2 band (albedo_strong_co2_fph) as described in Wunch et al. (2011).

2.5.2. Glint Data

Version 2.9 of the ACOS data is the first release that includes glint data that is recommended for use in scientific analysis. While the glint and land data show good general consistency, only very preliminary analyses have been carried out thus far, so it is impossible to say with certain at what level they agree over all regions of the globe. It appears that the relative difference between nadir and glint soundings degrades after April 19, 2011 (when the L1B data change to V130130).

The glint soundings can be identified using the "retrieval_results/surface_type" field in the Level 2 data files. If this field is "Coxmunk, Lambertian", the sounding is a glint observation. Unfortunately, the field "glint_flag" is carried forward from GOSAT flags, and does not correctly identify data that was processed with the ACOS glint algorithm. The ACOS project evaluates the solar geometry to identify glint and near-glint scenes. Thus, the 'surface_type' is the most accurate way to select glint data.

The actual algorithm used to select data to be processed as glint data is as follows: (a) land fraction is zero, (b) the absolute difference between the solar and sounding zenith angles is less than 2°, and (c) the solar minus the sounding azimuth angles (as defined in the ACOS granules) is between 160° and 200°.

2.5.3. GOSAT H- and M-Gain Data

The TANSO-FTS on the GOSAT satellite makes measurements in different modes. The medium gain (M-gain) is used over very bright surface scenes and is known to have ghosting issues (Suto and Kuze, 2010). These ghosting issues are expected to be corrected in the future, but for now it is recommended that only the "High gain" (H-gain) data from the ACOS data product be used in scientific analyses. The validation analysis by Wunch et al., [2011b] used only H-gain data to determine and correct the bias in the ACOS XCO_2 retrievals.

The gain setting can be determined by looking at the "RetrievalHeader/gain_swir" variable in the ACOS data product. Note that this variable has two character string entries per sounding – one for the S polarization and one for the P polarization.

3. Background Reading

3.1. About the GOSAT Mission

The Japanese GOSAT mission was successfully launched on January 23, 2009. The GOSAT prime mission extends five years from the date it was declared operational on April 19, 2009.

3.1.1. Instrument

The primary GOSAT science instrument is the Thermal And Near infrared Sensor for carbon Observation (TANSO). It is a Fourier-Transform Spectrometer (FTS) with 2-axis scanner. The scanner directs light into two sets of detectors within the instrument.

The Short Wave InfraRed (SWIR) detector is designed to measure the spectrum of reflected sunlight from both land and water surfaces. Three spectral regions are covered in two polarizations:

Band 1	.75 - .78 µm	Oxygen, a.k.a. ABO2
Band 2	1.56 – 1.72 µm	Weak CO_2, a.k.a. WCO2
Band 3	1.92 – 2.08 µm	Strong CO_2, a.k.a. SCO2

The Thermal InfraRed (TIR) detector is designed to measure the spectrum of thermal radiation from both land and water surfaces. A single spectral region is covered (5.5 – 14.3 µm). The ACOS Level 2 products do not include or utilize any TIR data.

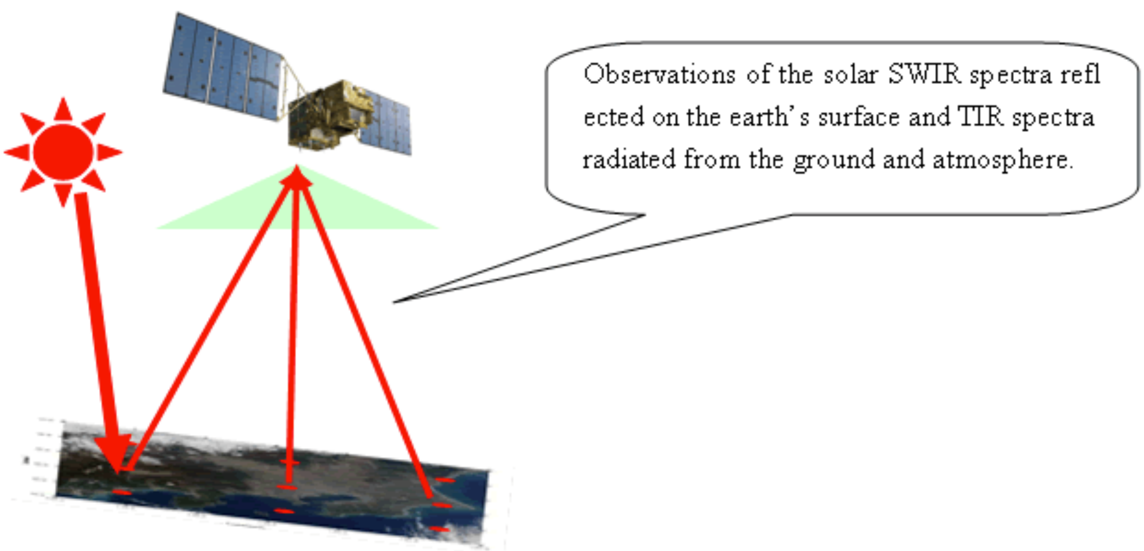

Figure 7. GOSAT Observation Concept

Orbital Parameters

GOSAT nominal orbit parameters are shown below.

- Orbit Type: sun-synchronous, ground track repeat, near-circular orbit
- Recurrent period: 3 days
- Recurrent orbit number: 44
- Revolutions per day: 14+2/3 rev/day
- Local sun time at descending node: 12:45 – 13:15 PM
- Altitude above equator: 665.96 km
- Orbital Period: 98.1 minutes
- Inclination: 98.06 degrees
- Eccentricity: 0.0 (Frozen orbit)
- Longitude at ascending node: Longitude 4.92 degrees west for orbit 1
- Footprint size on ground 10.5 km circle when NADIR viewing

Path ID Definition

The Path ID identifies the GOSAT orbit tracks on the ground. The detailed characteristics are as follows:

- A path begins at ascending node and extends to the next ascending node
- The ascending node of the Path with an ID of 1 is at longitude 4.92 degrees west
- The path number of the orbit tracks westward sequentially
- Path IDs run from 1 through 44
- Path calculator: https://data.gosat.nies.go.jp/map/html_E/MapPathCalendar.html

Note that Figure 8 illustrates 5-point sampling, which was used from April 2009 through July of 2010. Since August of 2010, a 3-point sampling mode has been used.

Points	Interval
1	789 km
3	263km
5 (nominal)	158km
7	113km
9	88km

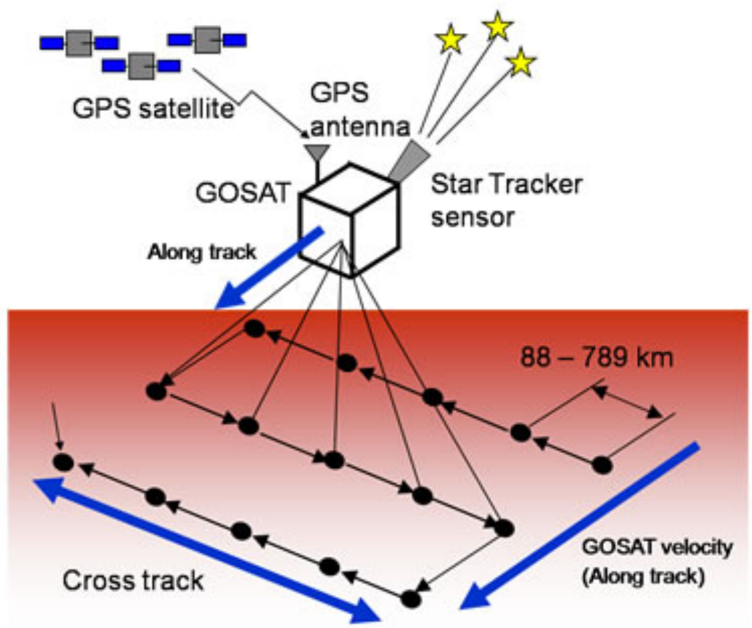

Figure 8. GOSAT TANSO-FTS Observation Details

3.2. GOSAT L1B Releases

The L1B radiance data are provided to the ACOS project by JAXA. As instrument characteristics are better understood, there have been some changes to the L1B data. Table 4 provides a high level view of the L1B versions and key characteristics. Section 3.5.1 shows how the L1B version that was used can be identified in the L2 product file name.

3.3. About the ACOS Task

The ACOS project is part of the Earth System Science Pathfinder (ESSP) Program in the NASA Science Mission Directorate (SMD). The Orbiting Carbon Observatory (OCO) was to have been the first NASA satellite designed to make global measurements of atmospheric carbon dioxide (CO_2) sources and sinks on regional scales at monthly intervals. The failure of the launch system and loss of the observatory therefore represented a setback to NASA's carbon cycle and climate science programs.

To meet its stringent CO_2 measurement accuracy requirements, the OCO Science Team developed and implemented several significant advances in ground-based calibration, validation, and remote sensing retrieval methods. These investments were not lost in the OCO launch failure and remain valuable NASA assets.

The OCO and GOSAT Science Teams formed a close partnership in calibration and validation activities. JAXA granted the ACOS Project access to GOSAT's calibrated Level 1B measurements. The ACOS Project applies the OCO calibration, validation, and remote sensing retrieval assets to analyze these GOSAT measurements. These analyses generate the Level 2 data products described herein.

Table 4. Description of the different GOSAT L1B releases.

Version	Period YYMMDD	Changes
Version006006 (P)	090423–090504 090516–090728	• initial version
Version007007 (P)	090405–090409 090419–090429 090716–091029	• SWIR spectrum unit is changed: (V -> V/cm-1) • SWIR phase correction parameter is changed. (Gauss function; 0.060000 -> 0.002000, see "TANSO Level 1Product Description Document" page 3-29) • Orbital data is changed. (predicted value -> fixed value) • Threshold of sun-glint cone angle is changed. (10 degrees -> 5 degrees) • New product items are added.
Version050050	090405–090409 090419–090503 090602–090731 091028–100208	• TIR phase correction (ZPD shift) • New item on spike noise judgment is added. • Threshold of saturation flag is changed. • Low-frequency correction. flag judgment is improved.
Version080080	090731–091001 100208–100316	• Calibration formula of TIR radiance spectrum are added. (But parameters are modified so that radiance values remain the same as those for V050.) • The accuracy of SWIR spike flag judgment is improved. • "CT_obsPoints" value is changed to "0X0a", when sensor mode is "specific point observation". As a result, it can be distinguished from the case of sensor anomaly. • AT/CT error angles are expressed in GOSAT/TANSO sensor coordinate. • Orbit and attitude parameters are changed.
Version100100	090930–091031 100315–110419	• "The major updated point on Ver.100_100 is that TIR phase correction. There are no change in SWIR processing so there is no difference in SWIR spectrum between current Ver.080_080 and Ver.100_100." - e-mail from Akihiro Matsushima
Version130130	110419–120418	• Preliminary Band-1 analog circuit non-linearity correction, based on ADC non-linearity implemented. • Adjustment of saturation detection. • Modification to TIR calibration.
Version141141	090601-100731	• Modified correction to Band-1 analog circuit non-linearity • Correction to the interferogram sampling interval uniformity • Improvement of TIR phase correction • Improvement of the Band-1 scan speed instability correction for medium gain (Gain M) data. • Processed using the 32-bit Level-1 processing system • No v2.9 ACOS Level 2 data products produced with this version of GOSAT L1B
Version150150	120419-120619	• Identical to v141141, but processed on the 64-bit L1B production processing system
Version150151	090423 -091031* 101224 -111130* 120620-current	• Identical to v150150, but with a corrected glint flag. • *All L1B data will be reprocessed to this version by December 2012.

The GOSAT team at JAXA produces GOSAT TANSO-FTS Level 1B (L1B) data products for internal use and for distribution to collaborative partners, such as ESA and NASA. These calibrated products are augmented by the ACOS Project with additional geolocation information and further corrections. These ACOS Level 1B products (with calibrated radiances and geolocation) are the input to the ACOS Level 2 production process.

The distribution of GOSAT and ACOS L1B products is currently restricted by cooperation agreements between JAXA and NASA.

3.4. ACOS Algorithms

In the sections that follow, the following definitions apply:

- Footprint – an observation by a single instrument
- Sounding – a combined observation of all instruments
- Granule – the construct expressing the content of a product (ACOS product granules contain all the processed GOSAT data for a single orbit)

Level 1B Algorithm Overview

The ACOS Level 1B (L1B) algorithm adds additional calibration information to the GOSAT TANSO-FTS Level 1B data, and converts these data to the format needed for the ACOS Level 2 algorithm. For example, the TANSO-FTS L1B is delivered with radiances expressed in engineering units (volts). JAXA provides a series of calibration tables that are used to convert these values from engineering units to the radiometric units used in the ACOS algorithm (photons/m^2/sr/cm^{-1}). The calibration information provided in these tables is derived from pre-launch calibration tests and on-orbit observations of internal light sources, deep space, the sun, the moon, and observations of calibration targets on the surface of the Earth. These tabulated results are assumed to be constant, or used to establish trends for time-dependent corrections.

Sounding and spacecraft geometric variables are included in the ACOS Level 2 products. Starting with v2.9, these geometric data are updated by the ACOS team, based on pointing error estimates provided by the GOSAT Project Team. As noted above, the pointing error tables applied to v2.9 are based on observations collected prior to December 2010, and are assumed to be constant in time. Some aspect s of the geolocation' is performed by the ACOS team based on standard Earth geoid shape and a high-resolution digital elevation model (DEM) and some is copied from the GOSAT input products.

ACOS does not currently process all soundings collected by GOSAT. Because the thermal IR data is not utilized in ACOS, only the soundings in the daylight portion of the GOSAT orbit are processed. This version of processing supports both nadir and glint soundings. Details of glint soundings are provided in section 2.5.2.

In addition, to restrict the attempted retrievals to those with adequate signal, the soundings are also screened by the expression "*sounding_solar_zenith* < 85".

Performing retrievals on scenes containing clouds will either fail or have skewed results (depending upon the extent of cloud coverage). Users should check the *cloud_flag* for the ACOS estimate of scene cloudiness. Many cloudy scenes that are inadvertently passed by the cloud screen algorithm will not converge during the processing and, therefore, will not appear in the Level 2 retrieval results.

Level 2 Algorithm Overview

The Full-physics XCO_2 retrieval algorithm is based on the one that was to be used for the Orbiting Carbon Observatory (OCO). The algorithm is a Rodgers [2000]-type optimal estimation approach and has been described fully in O'Dell *et al*. [2011]. The retrieval algorithm consists of a forward model, an inverse method, and an error analysis step. The overall flow for the retrieval process is shown in Figure 8.

The basic idea is to use a forward model to simulate all three bands of the OCO-2 spectrum then fitting the measured spectra to the model. The forward model contains components simulating the solar spectrum, atmospheric scattering and absorption, surface optical properties, radiative transfer, and detection by the instrument. The input to the forward model consists of meteorological conditions, surface properties, characteristics of the instrument, etc. Everything that is necessary to fully simulate the as-measured radiances must be input to the forward model.

The residuals between the simulated and measured spectra are minimized by changing parameters in the state vector via the inverse method. This inversion is relatively efficient because the forward model returns not just simulated radiances, but also partial derivatives of those radiances, also called Jacobians. The Jacobians are used by the inverse model to efficiently update the state vector in order to quickly find the state that minimizes the residuals.

Once the atmospheric state yielding the best match to the observed spectrum has been found, the algorithm then determines X_{CO2}, errors in X_{CO2} from different sources (such as vertical smoothing, measurement noise, etc.), and the X_{CO2} column averaging kernel. This is necessary because *xco2* is not itself an element of the state vector. Rather, it is determined from the profile of CO_2, which is part of the state vector. It is formally given by the total number of CO_2 molecules in the column divided by the total number of dry air molecules in the column. This step is labeled "Error Analysis" in Figure 9.

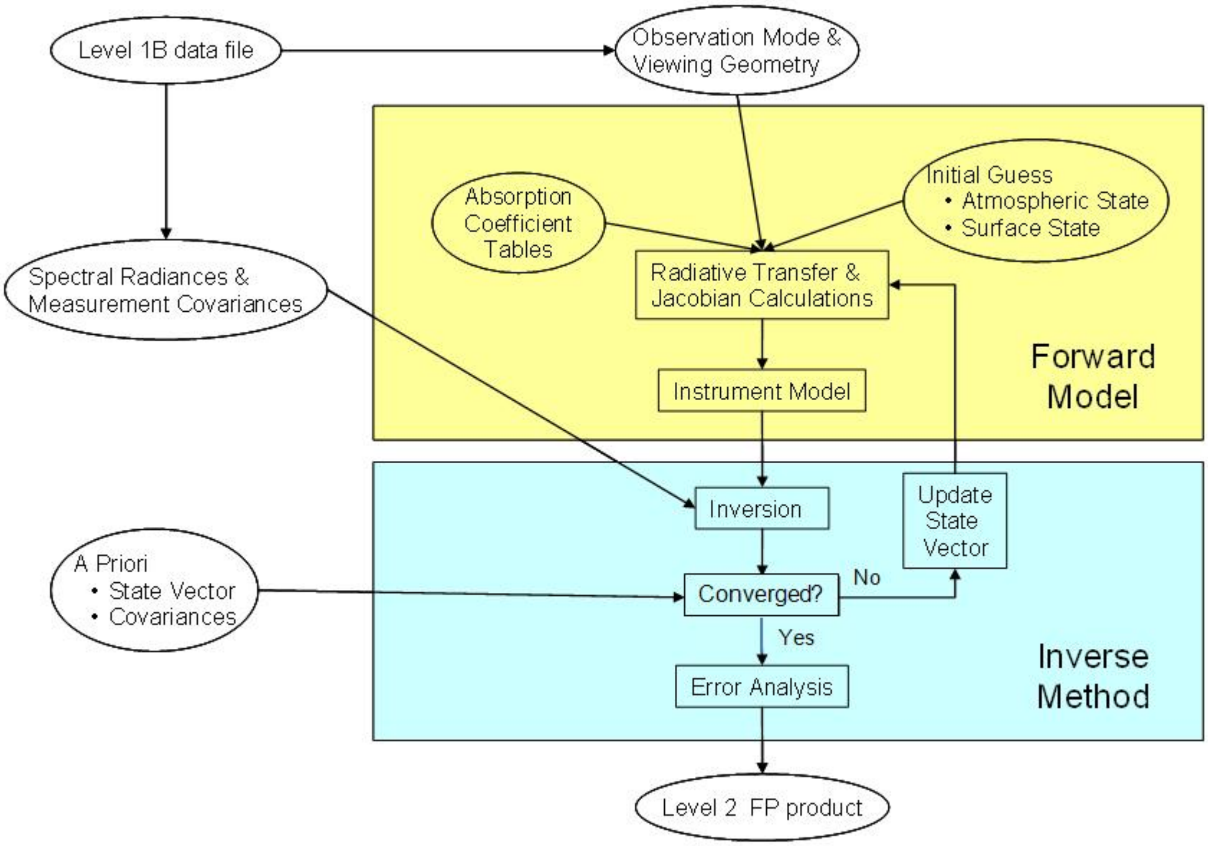

Figure 9. Level 2 Full Physics Retrieval Flow

3.5. ACOS Data Products

The ACOS Level 2 product set consists of products that focus on measuring column-averaged CO_2 dry air mole fraction (X_{CO2}). The measurements are extracted from observations made by JAXA's Greenhouse gases Observing SATellite (GOSAT). The global coverage that is achieved by GOSAT is repeated every three days at the highest resolution yet achieved from orbit.

3.5.1. File Naming Convention

ACOS Level 2 Product file name specification:

acos_ttt_date_nn_collection_productionTimeStamp**.h5**

Where:

- ttt = product type (L2s)
- date = observation date (yymmdd)
- nn = GOSAT path number (01-44)
- collection label, which consists of the following elements:
    - "Production": indicates a production product

  - v[nnn][mmm]: the TANSO-FTS L1B product version where [nnn] is the algorithm version and [mmm] is the parameter version
  - [software component][version] = the software component and version number that created the product. The software component for the final product is always 'L2s'. The version number for this release is '20900'.
  - r[nn] = the reprocessing level; initial production value is always '01'
  - Pol[x] = the polarization used for the retrievals; possible values are S, P, or B (both)
- productionTimeStamp = production date/time (UTC) at ACOS (yymmddhhmmss)

Filename examples:
acos_L2s_090724_07_Production_v110110_L2s2800_r01_PolB_101204185614.h5

acos_L2s_101102_43_Production_v100100_L2s20900_r01_PolB_111002175250.h5

By policy, *collection* will contain the software *build_id*. In addition, *collection* will also contain a data product version *rNN* in case the same product gets regenerated.

3.5.2. File Format and Structure

All ACOS Level 2 product files are in HDF-5 format, developed at the National Center for Supercomputing Applications http://www.hdfgroup.org/. This format facilitates the creation of logical data structures.

All ACOS Level 2 product files contain data structures indexed by sounding (1 to N soundings/file) and are associated by the *sounding_id* variable in all products.

Variables are combined into groups by type (e.g., SoundingGeometry). Within each type, a variable has one or more values per sounding. Variables may be single-valued (e.g., *sounding_altitude*) or multi-valued (e.g., *co2_profile*).

The metadata of each variable describes the variable's attributes, such as dimensions, data representation and units.

3.5.3. Data Definition

The ACOS Level 2 products contain many variables with a variety of dimensions. The following list describes only the most important of the dimensions.

- Retrieval — the number of retrievals reported (those soundings for which retrievals converged or were converging when the maximum number of iterations was reached)
- Polarization — the number of polarization states
- Level — the number of atmospheric retrieval levels
- Exposure — the number of scans in granule
- Band — the number of spectral bands
- Aerosol — the number of retrieval aerosol types

3.5.4. Global Attributes

In addition to variables and arrays of variables, global metadata is stored in the files. Some metadata are required by standard conventions, some are present to meet data provenance requirements and others as a convenience to users of the ACOS Level 2 Products. The most useful global attributes present in all files are shown in Table 5. Table 6 provides a list of key metadata fields for each variable.

Table 5. Some Global Metadata Attributes

Global Attribute	Type	Description
AscendingNodeCrossingDate	String	The date of the ascending node crossing immediately before the first exposure in the TANSO-FTS file. Format: yyyy-mm-dd
AscendingNodeCrossingTime	String	The time of the ascending node crossing immediately before the first exposure in the TANSO-FTS file. Format: hh:mm:ss.sssZ
StartPathNumber	32-bit integer	The first orbital path on which data contained in the product was collected.
EndPathNumber	32-bit integer	The last orbital path on which data contained in the product was collected.
ProductionDateTime	String	The date and time at which the product was created.
CollectionLabel	String	Label associating files in a collection.
HDFVersionId	String	For example 'HDF5 1.8.5'. A character string that identifies the version of the HDF (Hierarchical Data Format) software that was used to generate this data file.
BuildId	String	The identifier of the build containing the software that created the product.
TFTSVersion	String	The version of the TANSO FTS data used to create this data product.

Table 6. Key Metadata Items

Name	Type	Description
Name	String	The name of the variable
Shape	String	The set of dimensions defining the structure
Type	String	The data representation type
Units	String	The units of the variable.
Minimum	String	Smallest valid value of the variable
Maximum	String	Largest valid value of the variable

3.5.5. ACOS Metadata and Variables

This section contains tables describing the variables and metadata elements for the ACOS product.

Changes to the metadata fields in v2.9 are highlighted in the tables below.

Table 7. Metadata Information

Element	Shape	Storage	Bytes	Repetition	Comment
InputPointer	InputPtr_Array	String	255	5	The name of the data product that provides the major input that was used to generate this product.
TFTSVersion	Scalar	String	6	1	The version of the TANSO FTS data used to create this data product.
AncillaryDataDescriptors	AncFile_Array	String	255	5	An array of file names that specifies all of the ancillary data files that were used to generate this output product. Ancillary data sets include all input except for the primary input files.
AutomaticQualityFlag	Scalar	String	8	1	Reserved for future use.
CollectionLabel	Scalar	String	255	1	Label associating files in a collection
SizeMBECSDataGranule	Scalar	Float32	4	1	The size of this data granule in Megabytes.
StartPathNumber	Scalar	Int32	4	1	The first orbital path on which data contained in the product was collected.
StopPathNumber	Scalar	Int32	4	1	The last orbital path on which data contained in the product was collected.
AscendingNodeCrossingDate	Scalar	String	10	1	The date of the ascending node crossing immediately before the first exposure in the TANSO-FTS file. Format: yyyy-mm-dd
AscendingNodeCrossingTime	Scalar	String	13	1	The time of the ascending node crossing immediately before the first exposure in the TANSO-FTS file. Format: hh:mm:ss.sssZ
RangeBeginningDate	Scalar	String	10	1	The date on which the earliest data contained in the product were acquired. Format: yyyy-mm-dd
RangeEndingDate	Scalar	String	10	1	The date on which the latest data contained in the product were acquired. Format: yyyy-mm-dd
RangeBeginningTime	Scalar	String	13	1	The time at which the earliest data contained in the product were acquired. Format: hh:mm:ss.sssZ
RangeEndingTime	Scalar	String	13	1	The time at which the latest data contained in the product were acquired.
ProductionDateTime	Scalar	String	24	1	The date and time at which the product was created.
SISName	Scalar	String	255	1	The name of the document describing the contents of the product.
SISVersion	Scalar	String	8	1	The version of the document describing the contents of the product.

Table 7. Metadata Information

Element	Shape	Storage	Bytes	Repeti-tion	Comment
BuildId	Scalar	String	8	1	The identifier of the build containing the software that created the product.
GapStartTime	Gap_Array	String	24	10	Reserved for future use.
GapStopTime	Gap_Array	String	24	10	Reserved for future use.
QAGranulePointer	Scalar	String	255	1	A pointer to the quality assurance product that was generated with this product.
GranulePointer	Scalar	String	255	1	The name of the product.
LongName	Scalar	String	255	1	A complete descriptive name for the product.
ShortName	Scalar	String	16	1	The short name used to identify all data granules in a given data collection.
ProducerAgency	Scalar	String	4	1	'NASA' - Identification of the agency that provides the project funding
ProducerInstitution	Scalar	String	3	1	'JPL' - Identification of the institution that provides project management.
ProductionLocation	Scalar	String	20	1	Facility in which the file was produced: "Operations Pipeline", "Test Pipeline", "SCF", "Preflight Instrument Characterization", "Development", "Orbital", "Unknown"
ProductionLocationCode	Scalar	String	1	1	One-letter code indicating the *ProductionLocation*. The allowed values are: "" (null string) - Operations Pipeline s - SCF t - Test Pipeline c - Preflight Instrument Characterization d - Development o - Orbital x - Unknown
ProcessingLevel	Scalar	String	8	1	Indicates processing level. The allowed values are: Level 1A, Level 1B, Level 2

Table 7. Metadata Information

Element	Shape	Storage	Bytes	Repeti-tion	Comment
InstrumentShortName	Scalar	String	16	1	'TANSO-FTS' - The name of the instrument that collected the telemetry data.
PlatformLongName	Scalar	String	27	1	'Greenhouse gases Observing SATellite'
PlatformShortName	Scalar	String	3	1	'GOSAT'
PlatformType	Scalar	String	10	1	'spacecraft' - The type of platform associated with the instrument which acquires the accompanying data
ProjectId	Scalar	String	3	1	'ACOS' - The project identification string.
DataFormatType	Scalar	String	8	1	'NCSA HDF' - A character string that describes the internal format of the data product.
HDFVersionId	Scalar	String	3	1	'HDF5 vvvvvvv' - A character string that identifies the version of the HDF (Hierarchical Data Format) software that was used to generate this data file where vvvvvvv is a version id.
NumberOfExposures	Scalar	Int32	4	1	Actual number of points reported in the product
MissingExposures	Band_Polarization_Array	Int32	4	6	Number of expected points missing from the dataset
FirstSoundingId	Scalar	Int64	8	1	The *sounding_id* of the first sounding in the file
LastSoundingId	Scalar	Int64	8	1	The *sounding_id* of the last sounding in the file
NominalDay	Scalar	String	255	1	The approximate date on which the data were acquired. A *NominalDay* starts at an orbit boundary, so the *NominalDay* for some data do not match their calendar day. Format: yymmdd
OrbitOfDay	Scalar	String	255	1	The ordinal number of the orbit within its *NominalDay*, starting with 1.
SpectralChannel	Band_Array	String	24	3	The identifier of the spectral regions present in this granule. Allowed values are: '0.76um O2 A-band', '1.6um Weak CO2', '2.06um Strong CO2'
RetrievalPolarization	Scalar	String	1	1	Polarization used in TANSO-FTS measurements in this granule - "P", "S", or "B" (for Both).
L2FullPhysicsInputPointer	L2FullPhysicsInputPtr_Array	String	255	20	List of the input files used by the Full-physics algorithm code
L2FullPhysicsAlgorithmDescriptor	Scalar	String	255	1	A short description of the Full-Physics algorithm that was used to generate this product

Table 7. Metadata Information

Element	Shape	Storage	Bytes	Repeti-tion	Comment
L2FullPhysicsDataVersion	Scalar	String	3	1	Indicates the build version number of the Full-physics algorithm used.
L2FullPhysicsExeVersion	Scalar	String	6	1	Indicates the build version number of the Full-physics algorithm used.
L2FullPhysicsOperationsVersion	Scalar	String	6	1	Indicates the build version number of the Full-physics algorithm used.
VMRO2	Scalar	Float 32	4	1	The Volume Mixing Ratio of atmospheric O2 in units of Mole Mole^{-1}
RetrievalIterationLimit	Scalar	Int32	4	1	Maximum number of iterations allowed in the implementation of the retrieval algorithm
AerosolTypes	Aerosol_Array	String	30	4	Names of aerosol types used in retrievals (e.g., 'total', 'aero1')
NumberOfGoodRetrievals	Scalar	Int32	4	1	Number of retrievals with master_quality_flag of Good

Table 8 describes variables related to the position of the spacecraft at the observation time. Note that the variables have a Shape of 'Retrieval_Array'. Therefore, soundings are included only when retrievals converged or were converging when the maximum number of iterations was reached.

Table 8. Spacecraft Geometry Variables

Element	Shape	Type	Bytes	Repeti-tion	Unit	Min	Max	Comment
x_pos	Retrieval_Array	Float32	4	1	Meters			Spacecraft position in Earth Centered Rotating (ECR) coordinates at the start of the exposure.
y_pos	Retrieval_Array	Float32	4	1	Meters			Spacecraft position in Earth Centered Rotating (ECR) coordinates at the start of the exposure.
z_pos	Retrieval_Array	Float32	4	1	Meters			Spacecraft position in Earth Centered Rotating (ECR) coordinates at the start of the exposure.
x_vel	Retrieval_Array	Float32	4	1	Meters Second^{-1}			Spacecraft velocity in Earth Centered Rotating (ECR) coordinates at the start of the exposure.
y_vel	Retrieval_Array	Float32	4	1	Meters Second^{-1}			Spacecraft velocity in Earth Centered Rotating (ECR) coordinates at the start of the exposure.
z_vel	Retrieval_Array	Float32	4	1	Meters Second^{-1}			Spacecraft velocity in Earth Centered Rotating (ECR) coordinates at the start of the exposure.
spacecraft_lat	Retrieval_Array	Float32	4	1	Degrees	-90	90	Geodetic latitude of sub-spacecraft point at the start of the exposure.
spacecraft_lon	Retrieval_Array	Float32	4	1	Degrees	-180	180	Longitude of sub-spacecraft point at the start of the exposure.
spacecraft_alt	Retrieval_Array	Float32	4	1	Meters			Altitude of the spacecraft above the reference ellipsoid at the start of the exposure.
relative_velocity	Retrieval_Array	Float32	4	1	Meters Second^{-1}			The component of the relative SC/Target motion along the look-vector.
ground_track	Retrieval_Array	Float32	4	1	Degrees	0	360	Azimuth of the spacecraft ground track (measured from North)

Table 9 describes variables related to the instrument look vector or the intersection of the look vector with the Earth surface. Note that the variables have a Shape of 'Retrieval_Array'. Therefore, soundings are included only when retrievals converged or were converging when the maximum number of iterations was reached.

Table 9. Sounding Geometry Variables

Element	Shape	Type	Bytes	Repeti-tion	Unit	Min	Max	Comment
sounding_latitude_geoid	Retrieval_Array	Float32	4	1	Degrees	-90	90	Geodetic latitude of the center of the sounding based on standard geoid
sounding_longitude_geoid	Retrieval_Array	Float32	4	1	Degrees	-180	180	Longitude of the center of the sounding based on standard geoid
sounding_latitude	Retrieval_Array	Float32	4	1	Degrees	-90	90	Geodetic latitude of the center of the sounding based on PGS Toolkit topography
sounding_longitude	Retrieval_Array	Float32	4	1	Degrees	-180	180	Longitude of the center of the sounding based on PGS Toolkit topography
sounding_altitude	Retrieval_Array	Float32	4	1	Meters			Mean altitude of the surface within the sounding based on PGS Toolkit topography
sounding_altitude_max	Retrieval_Array	Float32	4	1	Meters			Maximum altitude of the surface within the sounding based on PGS Toolkit topography
sounding_altitude_min	Retrieval_Array	Float32	4	1	Meters			Minimum altitude of the surface within the sounding based on PGS Toolkit topography
sounding_altitude_uncert	Retrieval_Array	Float32	4	1	Meters			Uncertainty of the measure of altitude of the surface within the sounding based on the accuracy of the input information
sounding_altitude_stddev	Retrieval_Array	Float32	4	1	Meters			Standard deviation of the measure of altitude of the surface within the sounding
sounding_slope	Retrieval_Array	Float32	4	1	Degrees	0	90	Slope of the best-fit plane to the surface within the sounding.
sounding_plane_fit_quality	Retrieval_Array	Float32	4	1	Meters			Standard deviation for the tangent plane approximation
sounding_aspect	Retrieval_Array	Float32	4	1	Degrees	0	360	Azimuth of the surface projection of the slope surface normal
sounding_solar_azimuth	Retrieval_Array	Float32	4	1	Degrees	0	360	Azimuth of the sun at the center of the sounding based on topography
sounding_solar_zenith	Retrieval_Array	Float32	4	1	Degrees	0	90	Angle between the normal to the Earth geoid and the solar angle at the center of the sounding based on topography

Table 9. Sounding Geometry Variables

Element	Shape	Type	Bytes	Repeti-tion	Unit	Min	Max	Comment
sounding_azimuth	Retrieval_Array	Float32	4	1	Degrees	0	360	Azimuth of the vector toward the instantaneous position of the spacecraft from the center of the sounding based on topography
sounding_zenith	Retrieval_Array	Float32	4	1	Degrees	0	90	The angle between the normal to the Earth geoid and the vector toward the instantaneous position of the spacecraft from the center of the sounding based on topography
sounding_land_fraction	Retrieval_Array	Float32	4	1	Percent	0	100	Percent of land cover within the sounding.
sounding_glint_angle	Retrieval_Array	Float32	4	1	Degrees	0	180	The angle between the vector to the glint spot and the actual look vector.
sounding_at_angle	Retrieval_Array	Float32	4	1	Degrees	-180	180	Angle between the look vector and the spacecraft Y-Z plane. Positive angle is the right-hand screw direction of the Y-axis.
sounding_ct_angle	Retrieval_Array	Float32	4	1	Degrees	-180	180	Angle between look vector and the spacecraft X-Z plane. Positive angle direction is the right-hand screw direction of the X-axis
sounding_at_angle_error	Retrieval_Array	Float32	4	1	Degrees	-180	180	The difference between AT value derived by MMO and actual one is stored
sounding_ct_angle_error	Retrieval_Array	Float32	4	1	Degrees	-180	180	The difference between CT value derived by MMO and actual one is stored

The content of the Sounding Header (Table 10) has changed in v2.9. A number of retrieval-dimensioned fields have been moved to a new group titled "Retrieval Header"; see Table 11. This table now describes metadata that have the Shape 'Exposure_Array".

Therefore, soundings are included only when retrievals converged or were converging when the maximum number of iterations was reached. Those variables with a Shape including 'Exposure', however, include all soundings.

Table 10. Sounding Header Variables

Element	Shape	Type	Bytes	Repeti-tion	Comment
sounding_id	Exposure_Array	Int64	8	1	The unique identifier of the sounding.
cloud_flag	Exposure_Array	Int8	1	1	Estimate of scene visibility for this *sounding_id* taken from an ABO2-only clear sky retrieval: 0 - Clear, 1 - Cloudy, 2 - Undetermined
retrieval_index	Exposure_Array	Int32	4	1	Index into the Retrieval dimension of arrays in the RetrievalResults group for soundings associated with retrievals.
l2_packaging_qual_flag	Exposure_Array	BitField8	1	1	Bit Flags are used to record the status of each sounding during packaging of l2 output into retrieval arrays

Table 11 is new in v2.9. The Retrieval Header contains fields relocated from the Sounding Header and the Retrieval Results. This was done to co-locate all elements/variables with the Shape of Retrieval_Array. Soundings are included only when retrievals converged or were converging when the maximum number of iterations was reached.

Table 11. Retrieval Header Variables

Element	Shape	Type	Bytes	Repeti-tion	Comment
sounding_id_reference	Retrieval_Array	Int64	8	1	The sounding_id of the sounding containing the spectra used to perform the retrieval
exposure_index	Retrieval_Array	Int32	4	1	The index into the Exposure dimension of arrays in SoundingHeader, SoundingGeometry, and SpacecraftGeometry groups containing the spectra used to perform the retrieval
sounding_qual_flag	Retrieval_Array	BitFlag32	4	1	Single-bit quality flags
acquisition_mode	Retrieval_Array	String	4	1	The instrument mode in which the data in the product were collected. Valid values are: 'OB1D', 'OB1N', 'OB2D','SPOD','SPON','CALM','LUCA'
ct_observation_points	Retrieval_Array	Int8	1	1	Number of observation points in the cross track direction -1: undefined or specified observaton, 0: Electrical Calibration, "0x01" : 1 points "0x03" : 3 points "0x05" : 5 points "0x07" : 7 points "0x09" : 9 points
glint_flag	Retrieval_Array	Int8	1	1	This field is incorrect after YYYY-MM-DD. Use the glint filter described in section XXX instead of the glint_flag. Indicates whether GOSAT was in glint mode when acquiring the sounding 0 = Not in glint mode 1 = In glint mode
exposure_duration	Retrieval_Array	Float32	4	1	The duration of the exposure
sounding_time_string	Retrieval_Array	String	24	1	Representative sounding time, in the format yyyy-mm-ddThh:mm:ss.sssZ
sounding_time_tai93	Retrieval_Array	Float64	8	1	Sounding time in number of SI seconds since midnight, January 1, 1993.
gain_swir	Retrieval_Polarization_Array	String	5	2	Instrument gain setting for each polarization: H - High gain, M - Medium gain, L - Low gain, H_ERR - Error in setting high gain, M_ERR - Error in setting medium gain, L_ERR - Error in setting low gain, UNDEF - Gain set to an undefined state
spike_noise_flag	Retrieval_Band_Polarization_Array	Int8	1	6	0 - No spike noise present, 1 - Spike noise present
zpd_saturation_flag	Retrieval_Band_Polarization_Array	Int8	1	6	Copy exposureAttribute/pointAttribute/RadiometricCorrectionInfo/ZPD_SatiratopmFlag_SWIR

Table 12 describes variables expressing the retrieval results. Note that some of the variables have a Shape including 'Retrieval'. Therefore, soundings are included only when retrievals converged or were converging when the maximum number of iterations was reached.

In Table 12, *xco2* is calculated in the following way:

$$xco2 = \sum_{i=1}^{N_{num\_levels}} W_i CO2_i$$

where W_i represents *xco2_pressure_weighting_function* and $CO2_i$ represents *co2_profile*. The sum is over *num_levels*. W_i is a function primarily of the pressure level spacings, but also weakly of water vapor, and also depends on surface pressure.

Table 12. Variables Expressing Retrieval Results

Element	Shape	Type	Bytes	Repetition	Unit	Comment
num_active_levels (was num_levels)	Retrieval_Array	Int16	2	1		Number of levels in atmospheric model
master_quality_flag	Retrieval_Array	String	8	1		A string field with 4 possible values: "Good", "Caution" and "Bad", and a fourth value of "Failed" if a problem is seen in the sounding while it is being aggregated into the HDF product. Fixed length string, blank padded plus a null termination. See DFM by Greg Osterman titled "L2 Master Quality Flag", Nov 2 '10
surface_type	Retrieval_Array	String	19	1		"Lambertian" or " Coxmunk,Lambertian" This element can be used to determine whether a sounding is in glint mode (Coxmunk,Lambertian) or nadir (Lambertian).
surface_pressure_fph	Retrieval_Array	Float32	4	1	Pascals	Surface pressure
surface_pressure_apriori_fph	Retrieval_Array	Float32	4	1	Pascals	Apriori of surface pressure
surface_pressure_uncert_fph	Retrieval_Array	Float32	4	1	Pascals	Apriori of surface pressure
vector_pressure_levels	Retrieval_Level_Array	Float32	4	20	Pascals	Pressure altitude corresponding to each atmospheric level

Table 12. Variables Expressing Retrieval Results

Element	Shape	Type	Bytes	Repetition	Unit	Comment
iterations	Retrieval_Array	Int16	2	1		Number of iterations
dof_co2_profile	Retrieval_Array	Float32	4	1		Degrees of freedom (target gas profile only)
dof_full_vector	Retrieval_Array	Float32	4	1		Degrees of freedom (Full state vector)
outcome_flag	Retrieval_Array	Int8	1	1		Flag indication full physics outcome (more elaboration here)
xco2	Retrieval_Array	Float32	4	1	Volume Mixing Ratio	Column-averaged CO2 dry air mole fraction
xco2_apriori	Retrieval_Array	Float32	4	1	Volume Mixing Ratio	Apriori of column-averaged CO2 dry air mole fraction.
xco2_uncert	Retrieval_Array	Float32	4	1	Volume Mixing Ratio	Error in column averaged target gas dry air mole fraction
co2_profile	Retrieval_Level_Array	Float32	4	20	Volume Mixing Ratio	Vertical profile of CO_2
co2_profile_apriori	Retrieval_Level_Array	Float32	4	20	Volume Mixing Ratio	Vertical apriori profile of CO_2
co2_profile_uncert	Retrieval_Level_Array	Float32	4	20	Volume Mixing Ratio	Vertical profile of CO_2 uncertainty
xco2_uncert_noise	Retrieval_Array	Float32	4	1	Volume Mixing Ratio	Variance of target gas due to noise
xco2_uncert_smooth	Retrieval_Array	Float32	4	1	Volume Mixing Ratio	Variance of target gas due to smoothing
xco2_uncert_interf	Retrieval_Array	Float32	4	1	Volume Mixing Ratio	Variance of target gas due to interference
diverging_steps	Retrieval_Array	Int16	2	1		Number of iterations in which solution diverged
xco2_pressure_weighting_function	Retrieval_Level_Array	Float32	4	20		Pressure weighting function to form xco2
xco2_avg_kernel	Retrieval_Level_Array	Float32	4	20		Column averaging kernel
xco2_avg_kernel_norm	Retrieval_Level_Array	Float32	4	20		Normalized column averaging kernel
co2_profile_averaging_kernel_matrix	Retrieval_Level_Array	Float32	4	4000		Averaging kernel for co2 profile
co2_profile_covariance_matrix	Retrieval_Level_Array	Float32	4	4000	Mole^{2} Mole^{-2}	Covariance matrix for co2 profile
albedo_o2_fph	Retrieval_Array	Float32	4	1		Retrieved Lambertian component of albedo at at 0.77 microns
albedo_weak_co2_fph	Retrieval_Array	Float32	4	1		Retrieved Lambertian component of albedo at 1.615 microns
albedo_strong_co2_fph	Retrieval_Array	Float32	4	1		Retrieved Lambertian component of albedo at 2.06 microns

Table 12. Variables Expressing Retrieval Results

Element	Shape	Type	Bytes	Repetition	Unit	Comment
albedo_apriori_o2_fph	Retrieval_Array	Float32	4	1		Apriori of retrieved Lambertian component of albedo at 0.77 microns
albedo_apriori_weak_co2_fph	Retrieval_Array	Float32	4	1		Apriori of retrieved Lambertian component of albedo at 1.615 microns
albedo_aprioiri_strong_co2_fph	Retrieval_Array	Float32	4	1		Apriori of retrieved Lambertian componet of albedo at 2.06 microns
albedo_uncert_o2_fph	Retrieval_Array	Float32	4	1		Uncertainty of retrieved Lambertian component of albedo at 0.77 microns
albedo_uncert_weak_co2_fph	Retrieval_Array	Float32	4	1		Uncertainty of retrieved Lambertian componet of albedo at 1.615 microns
albedo_uncert_strong_co2_fph	Retrieval_Array	Float32	4	1		Uncertainty of retrieved Lambertian component of albedo at 2.06 microns
albedo_slope_o2	Retrieval_Array	Float32	4	1	Wavenumber^{-1}	Retrieved spectral dependence of Lamberion component of albedo within o2 channel
albedo_slope_weak_co2	Retrieval_Array	Float32	4	1	Wavenumber^{-1}	Retrieved spectral dependence of Lamberion component of albedo within weak co2 channel
albedo_slope_strong_co2	Retrieval_Array	Float32	4	1	Wavenumber^{-1}	Retrieved spectral dependence of Lamberion component of albedo within strong co2 channel
albedo_slope_apriori_o2	Retrieval_Array	Float32	4	1	Wavenumber^{-1}	Apriori of retrieved spectral dependence of Lamberion component of albedo within o2 channel
albedo_slope_apriori_weak_co2	Retrieval_Array	Float32	4	1	Wavenumber^{-1}	Apriori of retrieved spectral dependence of Lamberion component of albedo within weak co2 channel
albedo_slope_apriori_strong_co2	Retrieval_Array	Float32	4	1	Wavenumber^{-1}	Apriori of spectral dependence of Lamberion component of albedo within strong co2 channel
albedo_slope_uncert_o2	Retrieval_Array	Float32	4	1	Wavenumber^{-1}	Uncertainty of retrieved spectral dependence of Lamberion component of albedo within o2 channel
albedo_slope_uncert_weak_co2	Retrieval_Array	Float32	4	1	Wavenumber^{-1}	Uncertainty of retrieved spectral dependence of Lamberion component of albedo within weak co2 channel

Table 12. Variables Expressing Retrieval Results

Element	Shape	Type	Bytes	Repetition	Unit	Comment
albedo_slope_uncert_strong_co2	Retrieval_Array	Float32	4	1	Wavenumber^{-1}	Uncertainty of spectral dependence of Lamberion component of albedo within strong co2 channel
wind_speed	Retrieval_Array	Float32	4	1	Meters Second^{-1}	Retrieved Cox-Munk wind speed
wind_speed_apriori	Retrieval_Array	Float32	4	1	Meters Second^{-1}	Apriori of retrieved Cox-Munk wind speed
wind_speed_uncert	Retrieval_Array	Float32	4	1	Meters Second^{-1}	Uncertainty of retrieved Cox-Munk wind speed
h2o_scale_factor	Retrieval_Array	Float32	4	1		Retrieved scale factor for h2o profile
h2o_scale_factor_apriori	Retrieval_Array	Float32	4	1		Apriori of retrieved scale factor for h2o profile
h2o_scale_factor_uncert	Retrieval_Array	Float32	4	1		Uncertainty of retrieved scale factor for h2o profile
temperature_offset_fph	Retrieval_Array	Float32	4	1	Kelvin	Retrieved offset of temperature profile
temperature_offset_apriori_fph	Retrieval_Array	Float32	4	1	Kelvin	Apriori of retrieved offset of temperature profile
temperature_offset_uncert_fph	Retrieval_Array	Float32	4	1	Kelvin	Uncertainty of retrieved offset of temperature profile
dispersion_offset_o2	Retrieval_Array	Float64	8	1	Wavenumbers	Retrieved dispersion offset term in o2 channel
dispersion_offset_weak_co2	Retrieval_Array	Float64	8	1	Wavenumbers	Retrieved dispersion offset term in weak co2 channel
dispersion_offset_strong_co2	Retrieval_Array	Float64	8	1	Wavenumbers	Retrieved dispersion offset term in strong co2 channel
dispersion_offset_apriori_o2	Retrieval_Array	Float64	8	1	Wavenumbers	Apriori of retrieved spectral shift in o2 channel
dispersion_offset_apriori_weak_co2	Retrieval_Array	Float64	8	1	Wavenumbers	Apriori of retrieved dispersion offset term in weak co2 channel
dispersion_offset_apriori_strong_co2	Retrieval_Array	Float64	8	1	Wavenumbers	Apriori of retrieved dispersion offset term in strong co2 channel
dispersion_offset_uncert_o2	Retrieval_Array	Float32	4	1	Wavenumbers	Uncertainty of retrieved dispersion offset term in o2 channel
dispersion_offset_uncert_weak_co2	Retrieval_Array	Float32	4	1	Wavenumbers	Uncertainty of retrieved dispersion offset term in weak co2 channel

Table 12. Variables Expressing Retrieval Results

Element	Shape	Type	Bytes	Repetition	Unit	Comment
dispersion_offset_uncert_strong_co2	Retrieval_Array	Float32	4	1	Wavenumbers	Uncertainty of retrieved dispersion offset term in strong co2 channel
retrieved_aerosol_aod_by_type_high	Retrieval_Aerosol_Array	Float32	4	6		Retrieved column-integrated aerosol optical depth for each aerosol type for high altitudes
retrieved_aerosol_aod_by_type_mid	Retrieval_Aerosol_Array	Float32	4	6		Retrieved column-integrated aerosol optical depth for each aerosol type for high altitudes
retrieved_aerosol_aod_by_type_low	Retrieval_Aerosol_Array	Float32	4	6		Retrieved column-integrated aerosol optical depth for each aerosol type for high altitudes
retrieved_aerosol_aod_by_type	Retrieval_Aerosol_Array	Float32	4	4		Retrieved column-integrated aerosol optical depth for each aerosol type

Table 13 describes variables related to the analysis of the three spectral regions. Note that some of the variables have a Shape including 'Retrieval'. Therefore, soundings are included only when retrievals converged or were converging when the maximum number of iterations was reached.

In the descriptions below, "Reduced chi squared" is defined as:

$$\chi_r^2 = \frac{1}{N_{chan} - 5} \sum_{i=1}^{N_{chan}} \frac{(y_i - f_i(\hat{x})}{\sigma_i^2}$$

where N_{chan} is the number of GOSAT channels in the spectral region, y_i is the radiance value measured by GOSAT in channel i, σ_i^2 is the square of the uncertainty (or noise) in channel i, and $f_i(x)$ is the model of the radiance in channel i.

Table 13. Spectral Parameter Variables

Element	Shape	Type	Bytes	Repetition	Unit	Comment
residual_mean_square_o2	Retrieval_Array	Float32	4	1	W cm^{-2} sr^{-1} (cm^{-1})^{-1}	Root mean squares of residuals
residual_mean_square_weak_co2	Retrieval_Array	Float32	4	1	W cm^{-2} sr^{-1} (cm^{-1})^{-1}	Root mean squares of residuals
residual_mean_square_strong_co2	Retrieval_Array	Float32	4	1	W cm^{-2} sr^{-1} (cm^{-1})^{-1}	Root mean squares of residuals
signal_o2_fph (renamed: +_fph)	Retrieval_Array	Float32	4	1	W cm^{-2} sr^{-1} (cm^{-1})^{-1}	the signal level representative of the continuum level for this spectrum.
signal_weak_co2_fph (renamed: +_fph)	Retrieval_Array	Float32	4	1	W cm^{-2} sr^{-1} (cm^{-1})^{-1}	the signal level representative of the continuum level for this spectrum.
signal_strong_co2_fph (renamed: +_fph)	Retrieval_Array	Float32	4	1	W cm^{-2} sr^{-1} (cm^{-1})^{-1}	The signal level representative of the continuum level for this spectrum.
noise_o2_fph	Retrieval_Array	Float32	4	1	W cm^{-2} sr^{-1} (cm^{-1})^{-1}	
noise_weak_co2_fph	Retrieval_Array	Float32	4	1	W cm^{-2} sr^{-1} (cm^{-1})^{-1}	
noise_strong_co2_fph	Retrieval_Array	Float32	4	1	W cm^{-2} sr^{-1} (cm^{-1})^{-1}	
relative_residual_mean_square_o2	Retrieval_Array	Float32	4	1		Root mean squares of residuals over signal, i.e. sqrt [1/N * Sum[((MeasuredRadiance – ModelRadiance)/signal)^2] where N is the number of spectral elements in the band
relative_residual_mean_square_weak_co2	Retrieval_Array	Float32	4	1		Root mean squares of residuals over signal, i.e. sqrt [1/N * Sum[((MeasuredRadiance – ModelRadiance)/signal)^2] where N is the number of spectral elements in the band

Table 13. Spectral Parameter Variables

Element	Shape	Type	Bytes	Repeti-tion	Unit	Comment
relative_residual_mean_square_strong_co2	Retrieval_Array	Float32	4	1		Root mean squares of residuals over signal, i.e. sqrt [1/N * Sum[((MeasuredRadiance – ModelRadiance)/signal)^2] where N is the number of spectral elements in the band
reduced_chi_squared_o2_fph	Retrieval_Array	Float32	4	1		Reduced chi squared of spectral fit for ABO2 spectral region
reduced_chi_squared_weak_co2_fph	Retrieval_Array	Float32	4	1		Reduced chi squared of spectral fit for Weak CO2 spectral region
reduced_chi_squared_strong_co2_fph	Retrieval_Array	Float32	4	1		Reduced chi squared of spectral fit for Strong CO2 spectral region
snr_o2_l1b	Retrieval_Polarization_Array	Float32	4	2		Signal-to-noise ratio for ABO2 spectral region . from the L1b processing
snr_weak_co2_l1b	Retrieval_Polarization_Array	Float32	4	2		Signal-to-noise ratio for Weak CO2 spectral region
snr_strong_co2_l1b	Retrieval_Polarization_Array	Float32	4	2		Signal-to-noise ratio for Strong CO2 spectral region

Table 14 describes bit definitions for the two variables that are constructed as bit flags.

Table 14. Bit Flag Definitions

Element	Bit #	Content
l2_packaging_qual_flag	0	Spare
	1	Spare
	2	excluded during sounding selection
	3	skipped due to missing sounding file
	4	skipped due to failed sounding file pre-check
	5	failed due to sounding file read error
	6	Spare
	7	failed due to unexpected packaging error
sounding_qual_flag	0	Radiance calibration 0 = At least one band succeeded at least partially 1 = All three bands failed
	1	Geolocation 0 = Sounding geolocation succeeded 1 = Sounding geolocation failed
	2	Radiance calibration 0 = All three bands succeeded 1 = At least one band failed in at least one color
	3	Sounding geometry 0 = All parameters derived successfully 1 = Derivation failed
	4	Band ABO2 radiance calibration 0 = Successful 1 = At least on one color failed
	5	Band WCO2 radiance calibration 0 = Successful 1 = At least on one color failed
	6	Band SCO2 radiance calibration 0 = Successful 1 = At least on one color failed
	7	Sounding time derivation 0 = Successful 1 = Failed
	8	Derivation of surface parameters using DEM 0 = Successful 1 = Some parameters could not be derived
	9	Spacecraft position and velocity derivation 0 = Successful 1 = Failed
	10-31	Spare

4. Tools and Data Services

HDFView

HDFView is a Java based graphical user interface created by the HDF Group that can be used to browse all ACOS HDF products. The utility allows users to view all objects in an HDF file hierarchy, which is represented as a tree structure. HDFView can be downloaded or support found at: http://www.hdfgroup.org/hdf-java-html/hdfview/.

Mirador

The GES DISC provides basic temporal, advanced (event), and spatial searches through its search and download engine, Mirador (http://mirador.gsfc.nasa.gov). Mirador offers various download options that suit users with different preferences and different levels of technical skills. Users can start from a point where they don't know anything about these particular data, its location, size, format, etc., to quickly find what they need by just providing relevant keywords, like "ACOS", or "CO2".

Here is a direct link to the v2.9 ACOS science products on this site:

http://mirador.gsfc.nasa.gov/cgi-bin/mirador/collectionlist.pl?search=1&keyword=acos_l2s+2.9

Here are 2 methods to download the v2.9 collection:

1) Mirador Webpage

- Clicking the link above will display the collection for 2.9. Beneath the collection name, click the link "View Files"; this link will display all the files for v2.9. From here, click in the checkbox(es) to select the file(s) of interest. Click one of the buttons at the top to add the file(s) to the Cart. Doing this will update the page to show the data set collection name. On the Shopping Cart page, click the "Checkout" button. This will display the Download Data page with instructions on how to download the selected products.

2) Command-line

To build a list of ftp-paths to data files from the v2.9 collection, run the following Unix command:

```
wget "http://mirador.gsfc.nasa.gov/cgi-bin/mirador/granlist.pl?page=1&dataSet=ACOS_L2S&version=2.9&location=%28-90,-180%29,%2890,180%29&startTime=2009-03-30&endTime=2011-12-30&format=rss&maxgranules=100000" -nv -O - | sed -n '/>ftp:/ s|*</*link>||gp'
```

Note the time constrains, and the version, that can be changed as appropriate. The acquired list of ftp-paths to the data files can be used in a number of ways to download the files. The most convenient would be to use "wget" from Unix command-line:

wget –i list_of_files.txt

where the list of the ftp-paths was stored in the text file "list_of_files.txt"

Global Change Master Directory

Information about GOSAT/ACOS data can be researched alongside with other relevant collections in GCMD (Global Change Master Directory):

http://gcmd.nasa.gov/

or

http://gcmd.gsfc.nasa.gov/getdif.htm?GES_DISC_ACOS_L2S_V2.9

5. Contact Information

Contact information of the producer of the data products:

ACOS operations team: gdsops@nephthys.jpl.nasa.gov

Contact information for interpretation and usage of the data products:

ACOS data team: acos@jpl.nasa.gov

The following list is of related organizations, web sites or publications that may be beneficial to the user.

- Japanese Aerospace Exploration Agency:
  - http://www.jaxa.jp/projects/sat/gosat/index_e.html
- Japanese National Institute for Environmental Studies:
  - http://www.gosat.nies.go.jp/index_e.html

6. Acknowledgements, References and Documentation

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Figures 6 and 7 are taken from the JAXA press release "Greenhouse Gases Observing Satellite "IBUKI" (GOSAT) "First Light" Acquired by Onboard Sensors", February 9, 2009 (JST).

Links

The following list provides references to relevant documentation that users may find helpful.

- General GOSAT information:
  - http://www.jaxa.jp/projects/sat/gosat/index_e.html
  - http://www.gosat.nies.go.jp/index_e.html
  - http://www.gosat.nies.go.jp/eng/GOSAT_pamphlet_en.pdf
- Level 2 algorithm information:
  - ACOS Level 2 Algorithm Theoretical Basis Document, JPL D-65488
- Releases and publications:
  - http://www.jaxa.jp/press/2009/02/20090209_ibuki_e.html

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